B. N. Mandal University, Madhepura

Synopsis

On

“Study of Life Time of Black Holes and Expanding Universe”

by

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For

Ph.D. Degree in Physics (Faculty of Science)

Under the Supervision

of

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Synopsis for Ph.D Degree in Physics

(Faculty of Science)

1. Title of the Research Project:

"Study of Life Time of Black Holes and Expanding Universe"

1. Purpose and Need of the Study:

The study for the secret of the expanding universe is very complicated and facing so many challenges to know about the origin, evolution, expansion and other unknown information of the universe and its many constituents/components like solar system, stars, black holes, white dwarfs, neutron stars, galaxies etc. The discovery of quasars and other active galactic nuclei (AGN) in distant galaxies gives the beginning study and detailed information of spinning black holes. In this regards, some astrophysicists like Stephen Hawking, James Bardeen, Jacob Bekenstein & Carter developed of black hole thermodynamics and contributed the formulation of the laws of black hole mechanics. These laws provide us the equivalence relation between mass to energy, area to entropy, and surface gravity to temperature.

Taking some basic concepts of the research works of the greatest personality of Astrophysics discussed above as well as the subject matter like tensors, theory of relativity, ordinary thermodynamics and black hole thermodynamics, we propose to discuss some models which will help us to discuss the life time of black holes and our expanding universe. The work also discusses the comparative study of the life time of black holes in X-ray binaries (XRBs) and Active Galactic Nuclei (AGN) and universe regarding the current study with the ancient period of Hindu Methodology. The study also includes the Big-Bang Theory which is originated from the primordial black holes.

2. Details of the Research Project:

The present research work proposes to discuss some basic concept of some mathematical tools, theory of the relativity, ordinary laws of thermodynamics & black hole thermodynamics used for the study of the present research work**.**

The first law of black hole mechanics is given by the following equation **(Bardeen et al. 1973, Wald 2001, Narayan 2005, Mahto et al. 2012).**

$$dM = \frac{\kappa}{8\pi G} dA + \Omega dJ + \Phi dQ \quad \text{.....(1)}$$

where

κ =Surface gravity,

A = Area of event horizon.

J = Angular momentum.

Q = Change of black Holes.

ϕ = Electrostatic potential**.**

This shows the change in mass of black holes due to change in surface area, angular momentum and charge of the black holes.

The model for the change in entropy of the Fermionic, Bosonic Field of Black holes and other field of Black Holes are given by the following equations.

For spin parameters a* = +1/2 and -1/2, there are following two models **(Mahto et al 2020).**

$$\left(\frac{\delta S}{\delta M}\right)_{+1/2} = 9\pi M(1-M) \quad \text{. . . . . (2)}$$

$$\left(\frac{\delta S}{\delta M}\right)_{-1/2} = \pi M(7M+9) \quad \text{. . . . . -(3)}$$

For spin parameters a* = +3/2 and -3/2, there are following two models **(Mahto et al 2024).**

$$\left(\frac{\delta S}{\delta M}\right)_{+3/2} = -\pi M(51M - 17) \quad \ldots\ldots\ldots\ldots..(4)$$

$$\left(\frac{\delta S}{\delta M}\right)_{-3/2} = \pi M(51M + 17) \quad \ldots\ldots\ldots\ldots(5)$$

For spin parameters a* = +5/2 and -5/2, there are following two models **(Kumari,V et al. 2025).**

$$\left(\frac{\delta S}{\delta M}\right)_{+5/2} = -\pi M(165M - 33) \quad \ldots\ldots\ldots\ldots(6)$$

$$\left(\frac{\delta S}{\delta M}\right)_{-5/2} = \pi M(165M + 33) \quad \ldots\ldots\ldots\ldots(7)$$

Hence total six models are obtained due to Fermionic fields of black holes.

Similarly for Bosonic field of black holes of the spin parameters a* = +1 and -1, there are following two models **(Mahto et al 2020)**.

$$\left(\frac{\delta S}{\delta M}\right)_{+1} = -12\pi M(M - 1) \quad \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

$$\left(\frac{\delta S}{\delta M}\right)_{+1} = 12\pi M(M + 1) \quad \ldots\ldots\ldots\ldots\ldots\ldots(9)$$

For the spin parameters a* = +2 and -2, there are following two models as below **(Mahto et al 2024)**.

$$\left(\frac{dS}{dM}\right)_{+2} = -24\pi M(4M - 1) \quad \ldots\ldots\ldots\ldots\ldots (10)$$

$$\left(\frac{dS}{dM}\right)_{-2} = 24\pi M(M + 1) \quad \ldots\ldots\ldots\ldots\ldots\ldots(11)$$

For the spin parameters a* = +3 and -3, there are following two models**(Mahto et al 2024)**.

$$\left(\frac{dS}{dM}\right)_{+3} = -44\pi M(6M-1) \quad \text{. . . . . (12)}$$

$$\left(\frac{dS}{dM}\right)_{-3} = 44\pi M(6M+1) \quad \text{. . . . . (13)}$$

Hence total six models are obtained due to bosonic fields of black holes.

The life of the universe starts from the time of the Big bang. From that time the universe is expanding isotropically. This expansion is such that the distances between any pair of the galaxies are separated by more than 100Mpc. This separation is proportional to a universal scale factor denoted by a(t). Let us take the Hubble parameter (H) is defined by the following equation **(Mahto et al. 2020).**

$$H = \frac{\dot{\alpha}}{\alpha} \quad \text{, ... (14)}$$

where dot denotes the time derivatives. The current value of Hubble parameter (H) is H_0. This is known as Hubble constant. The galaxies are receding from us and away from each other. This is measured by the red shift defined by the quantity $z \equiv \Delta\lambda / \lambda$.

The model for life time of black holes is given by the following equation **(Hawking 1975)**.

$$\tau = 2.089\left(\frac{M}{M_{\otimes}}\right)^3 \times 10^{63}\, years \quad \text{.....(15)}$$

Hawking gave a revolutionary idea on the basis of quantum theory and said that the black holes are not black. They radiates energy and losses mass as per mass energy relation (**$E=mc^2$**). This radiation is known as Hawking radiation **(Hawking 1974)**.

Due to this emission of radiation, mass of Black Hole decreases and line area is also decreased and violated classical theory of Black Holes, became area of Black Holes never decrease according to classical theory of Black Holes.

On the basis of above proposed work, we shall study of our project work with suitable chapeterisation.

3.Chapterisation:

1. Introduction including background, review of literature, thesis organization and future plan of the research work.
2. Study of the entropy change with respect to mass of black holes.
3. Study of the life time of black holes.
4. The comparative study of Modern concept with ancient period of Life Time of Black holes.
5. Result and Discussion.
6. Conclusion and Future Aspect.
7. Biography / References.

4. Methodology:

The present research work is completely theoretical work based on fundamental postulates/principle/axioms of thermodynamics, theory of relativity and black hole thermodynamics using primary and secondary data taken from different research papers and literatures. In the present work, we have used the equations from (1) to (15) as the base of the work to study the life of black hole and universe and also the comparative study of modern concept with ancient period of life time of black holes along with related models to obtain our results proposed in our work.

5. Interdisciplinary Relevance:

The study of discussed above parameters of black holes has interdisciplinary relevance, because this study needs the depth knowledge of mathematics like

tensor analysis, theory of relativity, astrophysics as well as physical chemistry. The present work needs also the study of statistics & computer applications for statistical data analysis using computer system. Hence the present work has interdisciplinary importance to find out some new ideas and the secret of universe.

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I testify that I am in position to devote time for research work and undertake to complete the research work within specified maximum time limit.

(**Rohini Raj**)

Full signature of the Candidate with date

The candidate has undertaken to complete the research work under my supervision and guidance within the time limit.

Full signature of the Supervisor with date

Designation and Address.